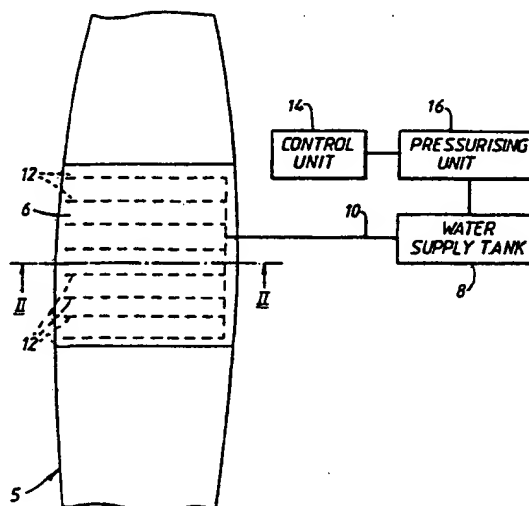


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(54) Title: EXTINGUISHING AND CONTROLLING FIRES IN THE AIRCRAFT CARGO BAY AREA

**(57) Abstract**

Apparatus for extinguishing or controlling fires in the cargo bay (6) of aircraft is disclosed. Water from a tank (8) is used as the extinguishing agent. An initial fire hazard may be detected by means of a smoke detector which activates a control unit (14) to cause an initial relatively short-duration water spray discharge into the cargo bay (6) through one or more spray lines (12). One or more parameters within the cargo bay (6) are then thereafter monitored (for example, temperature, infrared radiation, concentration of one or more particular gases) so as to detect if and when a fire hazard re-arises. When this is detected, a further relatively short-duration water spray discharge takes place. In this way, smouldering fires, which are the most common types of fire in an aircraft's cargo bay and which are difficult to extinguish completely while the aircraft is in flight (because of the limited quantity of extinguishant which can be carried), can at least be controlled until the aircraft lands.

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EXTINGUISHING AND CONTROLLING FIRES IN THE AIRCRAFT CARGO BAY AREA.

The invention relates to the extinguishing and the control of fires. Embodiments of the invention to be described in more detail are for use in extinguishing and controlling fires in the cargo bays of aircraft.

In use, the cargo bays of commercial aircraft contain a variable quantity of combustible material. This material may comprise commercial cargo or it may comprise luggage in the case of passenger aircraft; and in some cases a mixture of both types may be carried. Some means of safeguarding against fire in the cargo bay is required. Ideally, any such fire should be extinguished rapidly. However, in practice it may be very difficult actually to extinguish such a fire. The nature of the burning material is such that complete extinguishing may be very difficult during in-flight conditions. This is particularly so in the case of passenger luggage which, if a fire starts, is apt to smoulder and may be completely extinguished only by the application of a relatively great quantity of extinguishant - which cannot reasonably be carried by the aircraft. For these reasons, the regulatory authorities impose a requirement that a system must be installed on the aircraft which, broadly speaking, is capable of controlling a cargo bay fire such that it

will not reach a condition in which it is hazardous to the aircraft within a set period of time (three hours) which is sufficient to enable the aircraft to land whatever its position when the fire starts. When it has landed, more or less unlimited quantities of extinguishant can be deployed by the airport fire services to carry out a full extinguishing of the fire.

According to the invention, there is provided apparatus for protecting an aircraft from hazard following a fire condition arising in its cargo bay, comprising initial detection means for monitoring one or more parameters within the cargo bay to produce an initial detection signal upon detection of the onset of a fire hazard, extinguishant discharge means, means responsive to the initial detection signal for actuating the extinguishant discharge means to discharge extinguishant into the cargo bay for an initial time period, further detection means for thereafter monitoring one or more parameters within the cargo bay whereby to detect if and when a fire hazard re-occurs within the cargo bay so as to produce a respective further detection signal, and means responsive to the or each further detection signal for activating the extinguishant discharge means to discharge extinguishant into the cargo bay for a respective further time interval.

According to the invention, there is further provided a method of extinguishing or controlling fires within the cargo bay of an aircraft, comprising the steps of initially detecting the onset of a fire hazard by monitoring one or more predetermined parameters within the cargo bay, responding to such initial detection by carrying out an initial discharge of an extinguishant into the cargo bay for an initial time interval, subsequently monitoring one or more parameters within the cargo bay to detect further onsets of a fire hazard, and responding to the or each such further onset by causing a respective further discharge of an extinguishant into the cargo bay for a respective further time interval.

Apparatus embodying the invention, and methods according to the invention, for extinguishing or controlling fires in the cargo bays of aircraft, will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a plan view of the lower portion of an aircraft fuselage, showing the aircraft cargo bay and the apparatus installed therein, together with a schematic diagram of part of the apparatus;

Figure 2 is a cross-section on the line II-II of Figure 1;

Figure 3 is a graph for explaining operation of one form of the apparatus, plotting temperature in the cargo bay against fire extinguishant emission;

Figure 4 is another graph for explaining operation of the apparatus, plotting infra-red radiation in the cargo bay against fire extinguishant emission; and

Figure 5 is a further graph for explaining the operation of the apparatus, plotting the concentration within the cargo bay of carbon dioxide against fire extinguishant emission.

Figure 1 illustrates the lower part of the fuselage 5 of a large passenger-type commercial aircraft. The upper part of the fuselage (passenger cabin etc.) has been removed. The cargo bay is shown at 6. The exact shape of the cargo bay varies according to aircraft type. Figure 1 shows a single cargo bay 6. However, there may be several cargo bays distributed along the fuselage and isolated from each other to a greater or lesser extent.

In use of the aircraft, the cargo bay will (assuming the aircraft is a passenger aircraft) contain cargo consisting, in the main, of passengers' luggage in the form of cases mostly filled with tightly packed clothes

which, in the event of a fire, tend to burn slowly or smoulder. The amount of luggage within the cargo bay will vary greatly: the cargo bay may be nearly full of luggage or, at other times, it may be nearly empty.

If combustion should start within the cargo bay, which normally happens because of spontaneous combustion within a passenger's luggage (for example, as a result of the inclusion of hazardous substances perhaps reacting to jolting or air pressure changes within the cargo bay), there will be a serious risk to the aircraft. Such an occurrence may arise at any time, for example when the aircraft is over water and at maximum distance from the nearest airport. It is often the case that such fires are extremely difficult to extinguish. Because of the conditions within the cargo bay and, in particular within the passenger's case in which such a fire normally starts, and the materials (namely tightly packed clothing) involved in the fire, a relatively great quantity of fire extinguishant may be required for complete extinguishing of the fire. It is not possible for the aircraft to carry such large quantities of extinguishant. Therefore, the apparatus to be described is intended to ensure control of the fire for a period of, say, three hours which is sufficient to enable an aircraft to reach a safe landing, even if the fire starts when it is at maximum distance

from an airport. Such "control" has to ensure that the temperature within the cargo bay does not rise above a hazardous level - that is, a level which could cause hazard to the passengers and crew or damage to the essential services of the aircraft and to its structure.

The apparatus to be described uses water or other aqueous-based liquids as the fire extinguishing or controlling agent. Known systems use Halon 1301. However, the requirements of the Montreal Protocol relating to CFC's involve the phasing-out of the use of Halon 1301 wherever possible; and water or other aqueous agents have been found to be effective substitutes. However, other suitable non-aqueous liquid or pressurised gaseous fire extinguishants permitted under the Montreal Protocol may be used instead.

The water (or other extinguishant liquid) is carried in one or more tanks in the aircraft. If the aircraft has a water spray system for controlling fires in its passenger compartment, the water supply for the cargo bay apparatus may be common with the supply for the passenger compartment. Instead, or in addition, the water supply for the apparatus may be common with, or in an emergency connectable to, the so-called "grey" water supply system of the aircraft (for wash basin supply and the like).

Another possibility is to derive at least some of the water by extracting it from the air circulated by the aircraft's passenger bay air-conditioning system. For the purposes of illustration only, the water tank is illustrated at 8. An outlet 10 from the tank 8 leads to spray pipes 12 which, in this example, extend across the underside of the roof of the cargo bay (see Fig. 2). Each of these spray pipes comprises a plurality of spray nozzles spaced apart along its length.

Discharge of water into the cargo bay is controlled by a control unit 14 whose operation will be described in more detail below. In one form of the system, the control unit 14 causes actuation of the water spray by activating a pressurising unit 16 which pressurises the water in the tank and causes it to flow under pressure to the spray lines 12 and to be discharged into the cargo bay. In such an arrangement, actuation will cause discharge of water through all the spray lines 12. However, many modifications are possible. For example, the inlet to each of the spray lines 12 from the pipe 10 may incorporate a respective control valve. In such a case, the control unit 14 would be provided with means (to be described in more detail below) not only indicating a fire condition but also indicating the position of the fire within the cargo bay. By selectively operating

appropriate ones of the individual control valves, the control unit 14 responds by causing discharge of water only through the spray line or spray lines in the region of the fire.

If there is more than one cargo bay, then a similar arrangement may apply: the detection system would indicate the particular cargo bay in which the fire condition has arisen, and the control unit 14 would cause discharge of water through one or more spray lines in that cargo bay only (or in the relevant part of that cargo bay). In Figure 1, the various units of the apparatus are shown separate from the fuselage for ease of illustration but they would of course be carried on the aircraft.

The pressurising unit 16 may take any suitable form. For example, it could be in the form of a pyrotechnic gas generator which, when activated, generates gas pyrotechnically for pressurising the water. Such pyrotechnic gas generators are relatively light in weight (an important consideration for aircraft use) and do not require the continuous storage of pre-pressurised gas (with the weight penalty and the risk of leakage that this imposes). Such pyrotechnic gas generators are known for use in pressurising water spray systems for the passenger compartments of aircraft. However, water spray systems

for passenger compartments are required to be activated for a short period under landing or emergency landing conditions, for which application a pyrotechnic gas generator is particularly suitable. For the cargo bay apparatus being described, however, different conditions apply: the apparatus will be required to operate during normal flight conditions, and it is therefore reasonable to assume that normal aircraft power is available. Therefore, a pressurising pump driven from the aircraft's power supply could be used. Instead, stored gas pressure could be used.

As indicated above, the aim of the apparatus is to control any fire arising within the cargo bay to prevent it becoming hazardous. In a manner to be explained in more detail, the apparatus (a) detects the onset of a fire condition and responds to such detection by discharging a predetermined quantity of water into the cargo bay, or into the relevant part of the cargo bay, with the aim of reducing the fire condition to below the hazardous level, and (b) thereafter monitors at least one parameter within the cargo bay to determine if and when fire conditions within the cargo bay again become hazardous and, in response to any such occurrence, carries out a further discharge of water. The initial water spray may be sufficient to extinguish the fire completely. It may more

often be the case, though, that the fire condition will merely be partially suppressed; the fire will continue to smoulder and, once the initial water discharge has ceased, the fire may again become hazardous. If this occurs, this is detected (in a manner to be described) and a further water spray takes place with the aim of again reducing the fire condition below the hazardous level. Thereafter, further similar monitoring takes place and there may be further deployment of water spray. In this way, the apparatus continues to monitor conditions within the cargo bay and provides successive water sprays as necessary to keep the fire condition below the hazardous level. Because continuous monitoring takes place, water spray is only deployed when it is actually needed (to prevent the fire condition becoming hazardous). The most efficient use is made of the available quantity of water carried by the aircraft, with the aim of enabling the aircraft safely to land so that the fire can be fully extinguished. The apparatus thus contrasts with systems in which, in response to initial detection of a fire condition, an extinguishant such as Halon is discharged into the cargo bay, and thereafter either a trickle discharge of Halon continues or successive Halon discharges take place at predetermined time intervals. In each of these cases, extinguishant is not being used optimally; it may be being discharged unnecessarily, when the fire condition is not

hazardous, and this may mean that no extinguishant remains when the hazardous condition does arise.

In one form of the apparatus being described, the detection system includes one or more smoke detectors within the cargo bay for detecting the onset of an initial fire condition. The type of fire likely to arise is one which will produce a significant quantity of smoke. Therefore, one or more known types of smoke detector may be arranged within the cargo bay as operative, upon detection of smoke above a predetermined level, to cause the control unit 14 to initiate water spray discharge. Such discharge preferably takes place for a predetermined relatively short period of time (e.g. 1 to 15 minutes), say 6 minutes. Instead, however, the discharge could be terminated if detection shows that the fire has been reduced below a hazardous level. It is advantageous to commence the initial water discharge as soon as possible after detection of a fire condition; such early discharge is found to have optimum fire extinguishing effect. However, in order to avoid false alarms it may be advisable to have a second form of detection means within the cargo bay and to interconnect it with the smoke detector so that the initial water discharge does not take place until the detection of an initial fire condition, as indicated by excessive smoke level, has been confirmed by

the second fire detector. The second fire detector could be of any suitable type, such as a temperature sensor, a radiation sensor (infra-red or ultra-violet radiation) or a gas sensor, all to be described in more detail below.

As stated above, the apparatus is also operative to monitor the cargo bay after the initial fire condition and the initial water discharge, so as to detect if and when a hazardous fire condition re-occurs. Some means for continuing monitoring of the cargo bay is therefore required. It has been found that a smoke detector is not suitable for subsequent fire condition monitoring. This is because the type of fire likely to occur in the cargo bay may well completely fill the cargo bay with smoke, thus saturating the smoke detector and preventing its further effective operation.

One form of detector which has been found to be particularly suitable is a linear-type fire detector, for example a linear-type fire detector as sold under the trade mark FIREWIRE by the Applicants of the present application. Such a linear-type fire detector is deployed longitudinally through the area to be monitored and produces a warning signal if the temperature at any point along its length exceeds a predetermined level. Such a linear-type fire detector is advantageous in the present

instance in that it can be arranged to run alongside each spray line 12. In this way, a separate linear-type fire detector can be positioned to monitor the temperature alongside each of the spray lines 12 or alongside each of a group of them, thus permitting localised fire detection. Although each linear-type fire detector runs alongside each spray line, it should be thermally insulated from the spray line, because, otherwise, the cooling effect of the water within the spray line could produce a distorted result.

Figure 3 illustrates the use of such a linear-type of fire detector. Curve P represents the output of such a linear-type fire detector, this output representing temperature at a particular position within the cargo bay, for example along the length of a particular one of the spray lines 12, temperature being plotted along the vertical axis and time along the horizontal axis. The successive water discharges are indicated at A, B, C and D. A is the initial discharge of water. As shown, at this time the temperature detected by the linear-type fire detector is relatively low. This initial discharge is assumed to have been initiated solely by means of the smoke detector referred to above. Instead, however, it could be initiated by the smoke detector and the output of the linear-type fire detector in combination (in which

case it would of course occur later than shown in Fig. 3). As shown, the water discharge takes place for a relatively short period of time (about 6 minutes), at the end of which the temperature detected by the linear-type fire detector has reached a maximum and started to fall because of the effect of the water.

The temperature then tends to rise again, because of the continuing smouldering of the fire. When it reaches a hazardous level indicated at L1, it initiates a second water discharge, as indicated at B. This causes a rapid reduction in temperature and the water discharge is relatively short. The water discharge may take place for a predetermined relatively short period of time. Advantageously, however, it continues until the temperature falls to a predetermined level L2 (Fig. 3) less than the level L1 and is then automatically ended. In the same way, a further water discharge takes place at C. The discharges B and C are caused solely by the output of the linear-type fire detector; the smoke detector is not involved. Obviously, there will be further discharges if the temperature rises again.

Other types of fire detector may be used instead of the linear-type fire detector. For example, an infra-red detector, or several such detectors, may be arranged

within the cargo bay. Instead, ultra-violet detectors could be used, though are not considered to be so satisfactory; this is because of the not insignificant chance that the cargo bay will become completely filled with smoke which will prevent satisfactory operation of a UV detector. Other forms of temperature detectors can be used such as thermocouples.

Figure 4 shows at curve Q the output of an infra-red detector positioned within the cargo bay and indicates how the output of this, plotted on the vertical axis, causes the water discharges B and C. Again, the discharge A may take place solely as the result of the output from the smoke detector or from the output of the smoke detector in combination with the output of the infra-red detector.

It has also been found feasible to carry out continuing monitoring of fire conditions by gas analysis methods. Figure 5 shows the use of an analyser for monitoring carbon dioxide concentration. Curve R shows the variation of the concentration of CO_2 . Curve S shows the variation in the rate of change of the concentration of CO_2 . As shown in Figure 5, the initial water discharge A takes place when the smoke level rises above the predetermined minimum in the same way as for Figures 3 and 4. The subsequent water discharges B and C are initiated

when the rate of change of the carbon dioxide concentration (curve S) rises above a predetermined level L1 which indicates a potential fire hazard. Each such discharge ends when the rate of change of CO₂ concentration falls below a level L2.

Variations in the actual CO₂ concentration (curve R) could instead be used as a means of detecting hazardous fire conditions as shown. However, it is found to be relatively difficult to set the thresholds L1 and L2 for gas concentration but easier to set thresholds L1 and L2 for rate of change of gas concentration. Rapid changes of concentration take place when a smouldering fire increases in intensity.

Instead of using an analyser of carbon dioxide concentration, an analyser of carbon monoxide may be used, the carbon monoxide concentration generally following the carbon dioxide concentration. Another possibility is to monitor oxygen concentration - which of course reduces instead of increases in the presence of increased fire hazard. Water discharges would be controlled by variations in the carbon monoxide or oxygen concentration or in the rate of change of carbon monoxide or oxygen concentration.

In the case shown in Figure 5, the initial water discharge A takes place either as a result of operation of the smoke detector alone or a combination of the operations of this detector and some other detector, such as the carbon dioxide detector.

Tests have shown that there is a high correlation between the instances when gas analysis detectors (of the type used for Figure 5 for example) indicate a fire hazard and the instances when more directly operating types of fire detector, such as temperature detectors, indicate such hazards. It is therefore shown that gas analysis detectors are effective in this particular operation.

It may be advantageous, particularly when using linear-type fire detectors (see Figure 3), to monitor not merely the temperature detected by the detector but also the rate of change of temperature (measured by the rate of change of the detector's output). A very rapid rise in temperature can be used to indicate a hazardous fire condition.

Advantageously, the sprayed water contains one or more additives. For example, it may contain anti-freeze. In addition, it may contain fire-retarding agents such as disclosed in our co-pending United Kingdom Patent

Application No. 9114504. Other additives which may be used are surface-active materials and wetting agents such as described in this co-pending application. Such additives may be mixed with the water in the tank 8 (Figure 1) or may be stored separately and added in metered quantities when the water is actually discharged.

The latter arrangement is more suitable where the water supply is common to the water supply used for passenger bay fire protection or for the aircraft's "grey" water supply; in the latter two applications, it would not be satisfactory for additives to be used.

Advantageously, means are provided in the floor of the cargo bay for collecting the discharged water, or at least some of it, filtering it, and returning it to the tank 8 for re-use.

If a suitable pressurized gas is used as the extinguishant, the form of apparatus indicated in Figure 1 would be modified correspondingly.

CLAIMS

1. Apparatus for protecting an aircraft from hazard following a fire condition arising in its cargo bay (5), comprising initial detection means for monitoring one or more parameters within the cargo bay to produce an initial detection signal upon detection of the onset of a fire hazard, extinguishant discharge means (12), and means (14) responsive to the initial detection signal for actuating the extinguishant discharge means (12) to discharge extinguishant into the cargo bay (5) for an initial time period, characterised by further detection means for thereafter monitoring one or more parameters within the cargo bay (5) whereby to detect if and when a fire hazard re-occurs within the cargo bay (5) so as to produce a respective further detection signal, and means (14) responsive to the or each further detection signal for activating the extinguishant discharge means (12) to discharge extinguishant into the cargo bay (5) for a respective further time interval.
2. Apparatus according to claim 1, characterised in that each further time interval is of fixed duration.
3. Apparatus according to claim 1, characterised in that each further time interval ends when the further detector

means detects that the respective fire hazard has ended.

4. Apparatus according to any preceding claim, characterised in that the parameter or one of the parameters monitored by the initial detection means comprises smoke.

5. Apparatus according to any preceding claim, characterised in that the or each parameter monitored by the further detection means is different from the parameter or at least one of the parameters monitored by the initial detection means.

6. Apparatus according to any preceding claim, characterised in that the or one of the parameters monitored by the further detection means comprises temperature.

7. Apparatus according to claim 6, characterised in that the or one of the parameters monitored by the further detection means comprises rate of change of temperature.

8. Apparatus according to claim 6 or 7, characterised in that the further detection means comprises linear-type fire detection means.

9. Apparatus according to any one of claims 1 to 5, characterised in that the or one of the parameters monitored by the further detection means comprises electromagnetic radiation such as infra-red radiation or ultra-violet radiation.

10. Apparatus according to any one of claims 1 to 5, characterised in that the or one of the parameters monitored by the further detection means comprises rate of change of electromagnetic radiation such as infra-red radiation or ultra-violet radiation.

11. Apparatus according to any one of claims 1 to 5, characterised in that the parameter or one of the parameters monitored by the further detection means comprises the concentration of a particular gas within the cargo bay (5).

12. Apparatus according to any one of claims 1 to 5, characterised in that the parameter or one of the parameters monitored by the further detection means comprises the rate of change of concentration of a particular gas within the cargo bay.

13. Apparatus according to claim 11 or 12, characterised in that the particular gas is carbon dioxide.

14. Apparatus according to claim 11 or 12, in that the particular gas is carbon monoxide.

15. Apparatus according to claim 11 or 12, characterised in that the particular gas is oxygen.

16. Apparatus according to any preceding claim, characterised in that the extinguishant is a liquid and the extinguishant discharge means (12) comprises liquid spray means.

17. Apparatus according to claim 16, characterised in that the liquid spray means comprises one or more linear spray lines (12) mounted within the cargo bay (5) and running along an upper part thereof.

18. Apparatus according to claims 8 and 17, characterised in that the linear-type detection means comprises a respective linear-type detector running alongside the or each spray line (12).

19. Apparatus according to any preceding claim, characterised in that the extinguishant is water or an aqueous-based liquid.

20. Apparatus according to claim 19, characterised in

that the water is derived from a supply thereof which is common to another water-use system on the aircraft.

21. Apparatus according to claim 19, characterised in that at least some of the water is extracted from the aircraft's air-conditioning system.

22. Apparatus according to claim 19, 20 or 21, characterised in that the water or aqueous-based liquid discharged by the extinguishant discharge means (12) includes one or more predetermined additives, such as anti-freeze, fire retardant and surface-active additives.

23. Apparatus according to any one of claims 19 to 22, characterised by means within the cargo bay (5) for collecting water therein after its discharge by the extinguishant discharge means (12) and for re-circulating it to the extinguishant discharge means (12).

24. Apparatus according to any one of claims 1 to 16, characterised in that the extinguishant is a pressurised gas.

25. A method of extinguishing or controlling fires within the cargo bay (5) of an aircraft, comprising the steps of initially detecting the onset of a fire hazard by

monitoring one or more predetermined parameters within the cargo bay, and responding to such initial detection by carrying out an initial discharge of an extinguishant into the cargo bay for an initial time interval, characterised by the steps of subsequently monitoring one or more parameters within the cargo bay (5) to detect further onsets of a fire hazard, and responding to the or each such further onset by causing a respective further discharge of an extinguishant into the cargo bay for a respective further time interval.

26. A method according to claim 25, characterised in that the or one of the parameters monitored during the initial detection step is smoke.

27. A method according to claim 25 or 26, characterised in that the or each parameter monitored during the or each subsequent monitoring step is different from the parameter or at least one of the parameters monitored during the initial detection step.

28. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step comprises temperature.

29. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step comprises rate of rise temperature.

30. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step comprises electromagnetic radiation such as infra-red radiation or ultra-violet radiation.

31. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step comprises rate of rise electromagnetic radiation such as infra-red radiation or ultra-violet radiation.

32. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step comprises the concentration of a particular gas, such as carbon dioxide, carbon monoxide or oxygen.

33. A method according to any one of claims 25 to 28, characterised in that the or one of the parameters monitored during the or each subsequent monitoring step

comprises the rate of rise concentration of a particular gas, such as carbon dioxide, carbon monoxide or oxygen.

34. A method according to any one of claims 25 to 33, characterised in that the extinguishant is a sprayed liquid.

35. A method according to claim 34, characterised in that the sprayed liquid is water.

36. A method according to claim 35, characterised in that at least some of the water is water extracted from the aircraft's air-conditioning system.

37. A method according to claim 35 or 36, characterised by the step of collecting and recycling discharged water.

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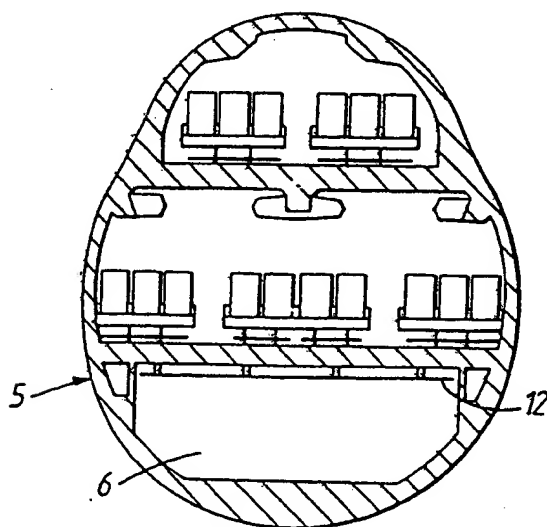
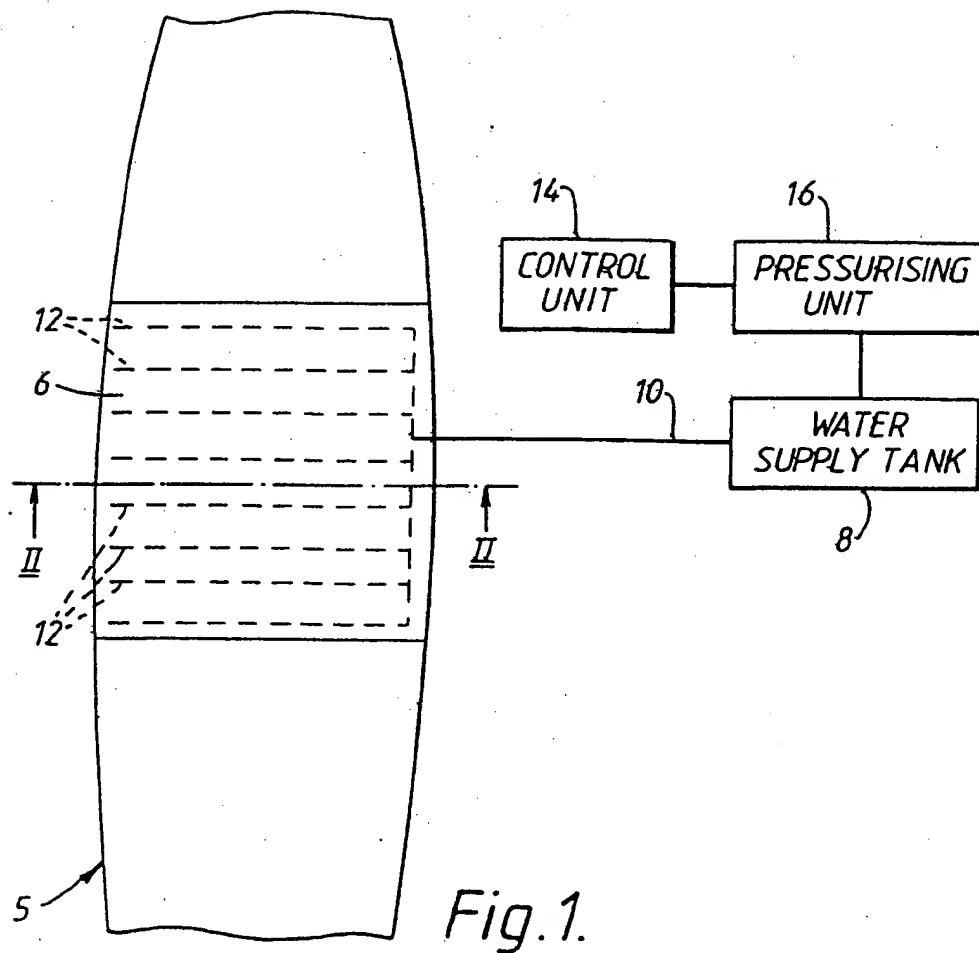


Fig. 2.

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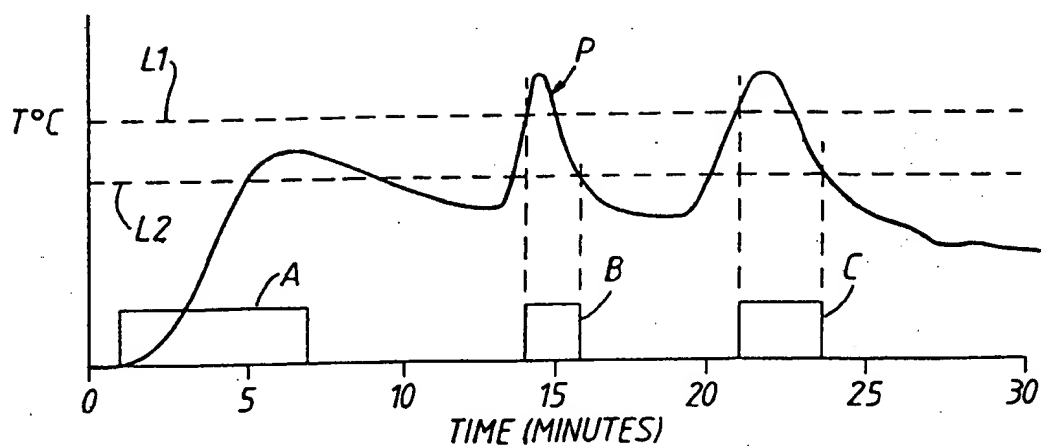


Fig.3.

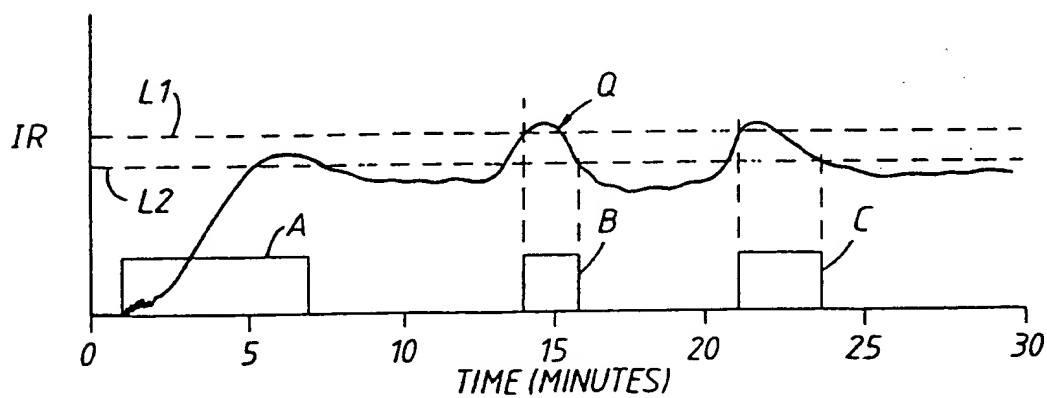


Fig.4.

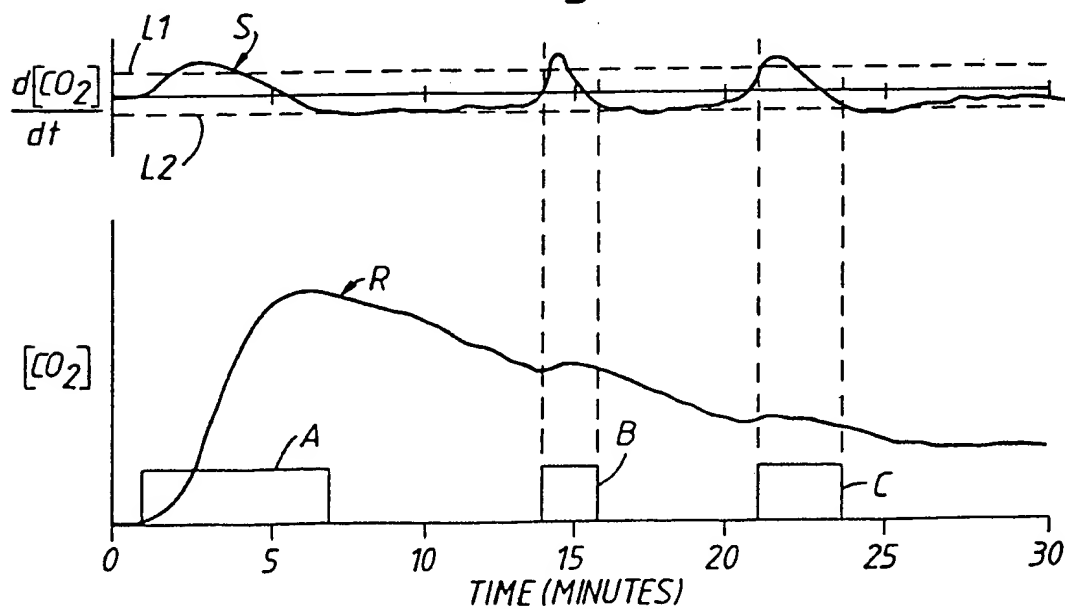


Fig.5.

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 A62C3/08; A62C37/40		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	A62C	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	US,A,4 005 754 (LINDEN ET AL.) 1 February 1977 see the whole document	1-6, 9, 16, 19, 25-28, 30, 34, 35
A	US,A,4 643 260 (MILLER) 17 February 1987 see the whole document	1, 25
A	EP,A,0 452 057 (PACIFIC SCIENTIFIC CO.) 16 October 1991 see the whole document	1, 9, 25, 30
A	WO,A,9 107 208 (KIDDE-GRAVINER LTD.) 30 May 1991	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search <div style="text-align: center; font-weight: bold;">09 MARCH 1993</div>	Date of Mailing of this International Search Report <div style="text-align: center; font-weight: bold;">16. 03. 93</div>	
International Searching Authority <div style="text-align: center; font-weight: bold;">EUROPEAN PATENT OFFICE</div>	Signature of Authorized Officer <div style="text-align: center; font-weight: bold;">DIMITROULAS P.</div>	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9202321
SA 67834

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4005754	01-02-77	None	
US-A-4643260	17-02-87	None	
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